Title: DEVELOPMENT OF THE METHOD OF CONSTRUCTING HYDROELECTRIC POWER PLANTS WITH THE HYDRO UNITS INCORPORATED IN THE PIERS, AND ITS HYDRAULIC CHARACTERISTICS by Milo Goljevscek, Engr (Yugoslavia)

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DEVELOPMENT OF THE METHOD OF CONSTRUCTING HYDROELECTRIC POWER ~~STATIONS~~ PLANTS WITH THE HYDRO UNITS INCORPORATED IN THE PIERS, AND ITS HYDRAULIC CHARACTERISTICS

Engr. Milo Goljevscek

The so-called classic method of hydroelectric power ~~station~~ plant construction prevailed in the construction of low-head river power ~~stations~~ plants until a short time ago. This method of construction appears most often in the following two variations.

In the first instance, the powerhouse is located outside the river bed in a separate artificially created bay, as at the Fala and the Kachlet hydroelectric power ~~stations~~ plants on the Danube at Passau, Austria. This type of construction is used if the river bed is narrow.

In the second instance, the powerhouse and the dam are installed in the river bed, as at the Schworstadt Hydroelectric Power ~~Station~~ Plant on the Rhine in Switzerland. This type of construction can be used when the river bed is sufficiently wide.

In both instances, the machinery for controlling the dam gates is directly connected with the dam and all machinery units are located in a machine room.

Rapid progress was made in the construction of turbines and generators after World War I. Parallel to this progress was the tendency to decrease the number of machine units in the large power ~~stations~~ plants.

America began to abolish the construction of turbine houses for some large river power ~~stations~~ plants immediately after World War I. The Mitchell, Alabama, Hydroelectric Power ~~Station~~ Plant has no turbine houses. Its turbines and generators are located in vertical shaft units. A large gantry crane is used for transport, assembly and dismantling of turbines, generators, and dam gates. The generator is assembled above ground and installed in a very small room. Regulators, exciters, servomotor pumps, boiler rooms, and air cooling rooms are installed underground. In case of mechanical failure, the faulty machinery is raised by a crane.

Sweden went even further by lowering the generator to the intermediate floor so that only roof-covered installation openings remain. The Vargon Hydroelectric Power ~~Station~~ Plant in Switzerland, built in 1930, is a well-known example of a low-head hydroelectric power ~~station~~ plant without turbine houses.

A further development of the classic method of construction is demonstrated at the Labud hydroelectric Power ~~Station~~ Plant on the Drava River in Austria, where the so-called pier type of construction was uded. Each turbine is located in the interior of a hollow sluice pier. Turbines and generators are assembled and dismantled by means of a gantry crane through openings in the ceiling, the openings being covered with reinforced concrete roofs.

A model of this type of construction, based on the Maribor~~Island~~ski otok Hydroelectric Power ~~Station~~ Plant on the Drava River near Maribor, was investigated by the author in the Hydrotechnical Laboratory of the University of Ljubljana in 1946 and revealed the following:

1. The water connection with all discharge openings is very stable in the closed or open position, with the result that the water connection with individual conduits into the turbines is very stable whatever the water level.

2. Spillways excavated under the discharge areas are satisfactory for dissipating the force of the falling water and standardizing its velocity. Thus, the action of the spillway is stable and independent of the falling level on the tailwater side of the river which may occur because of the natural erosion of the river bed.

3. The most characteristic phenomenon of the new pier system, and the most destructive for the river bank, is the tide caused by the headwater falling into the tailwater side of the river. The more peaceful the flow of the water along the bank, the more violent the tide formed and the stronger the waves against the bank. Convincing proof of the power of this tide was given on 9 July 1946 when it destroyed the breakwater for more than 100 meters below the Dravograd Hydroelectric Power ~~Station~~ Plant.

4. The discharge of high water from the spillway into the tailwater side of the river shows a hydrodynamic turbulence second to that of the tide. Therefore, the turbine piers are built very wide, from 15 to 20 meters, and the suction pipes are from 45 to 65 meters long measured from intake to discharge. The turbine piers of the Maribor ~~Island~~ski otok plant are 60 meters long and block 41 percent of the width of the discharge dam.

Rules for the simultaneous symmetrical and nonsymmetrical operation of the dam gates for the pier type of construction are very valuable and necessary.

5. The turbine conduits are protected from the rush of floating objects by a fine-mesh screen and reinforced concrete walls. These walls, shaped like balconies, stretch into the ~~high~~ head water to a depth of 1.5 meters 12 to 16 meters in front of the screen.

6. Deposits of gravel, which collect in front of the turbine conduits should be cleaned only when the ~~high~~ head water is not at full peak.

7. The new system is not unlike the classic system in loss of power capacity at high water.

8. The pier system shows favorable possibilities for construction by degrees which the classic system does not possess. During the second phase of construction by the pier system, it is possible to put two thirds of all turbine installations into operation at full capacity, thus shortening the nonrevenue-producing period by a third.

Ideas on the future development or modification of the pier system of construction are as follows:

1. The new system makes possible the construction of river power ~~stations~~ plants on all larger rivers which have a sufficient quantity of usable water. If a power plant with three turbine units is taken as a basic one, individual units should admit maximum quantities of water, the lowest limit being at least 50 cubic meters.

2. In broader contours, it will be necessary to interpose regular piers [gates] with the turbine piers thus changing the pier system to a combined pier system. In this case, a large number of discharge areas will carry off the headwater, the required water storage being attained by a slight raising of the level of the dam.

A combined system is uneconomical where contours are too broad because of the excessive length of the dam. An economical choice can be based only on an economical arrangement of the level of the dam, which should be 8 to 10 meters at the lowest.

A simple pier system can be considered for narrow rivers. Here, too, the level of the dam, the discharge of all discharge areas, and the highest discharge should be taken into account. In this system, the level of the dam can be over 20 meters. However, if the dam is over 14 meters high, account must be taken of the necessity of raising the location of the discharge openings in the downstream side above the level of the lowest headwater.

If geological or other circumstances do not permit using a dam high enough to store the maximum headwater, the simple pier system should be modified so that a larger discharge contour in the river bed can be attained through the level permissible for the dam. An increase in the storage capacity of discharge areas is further attained by widening the dam by excavation.

If the disposition of turbine piers is not satisfactory for leading off disastrously high waters, then it is necessary to change to a system of cylindrical turbine housings.

If a simple pier system is desired to be used in a narrow contour, storage capacity and discharge can be increased by means of a canal under the foundations of the turbine piers. With the discharge of excess high water through such a canal, the water from the suction pipes can act as an ejector on account of its velocity and under favorable circumstances prevent a visible lowering of the power station's effectiveness at high water.

The canal in question serves further for cleaning or leading away the deposits in front of the turbine intake gates, which can be done without lowering the level of the headwater. This cleaning action can also be accomplished by opening all dam gates and sacrificing the total accumulated volume.

The last and most important argument for the value of the canal ~~chamber~~ under the foundations is that it allows a larger additional quantity of water to enter the water chamber and equalizes the volume of the discharge areas and the turbine piers.

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